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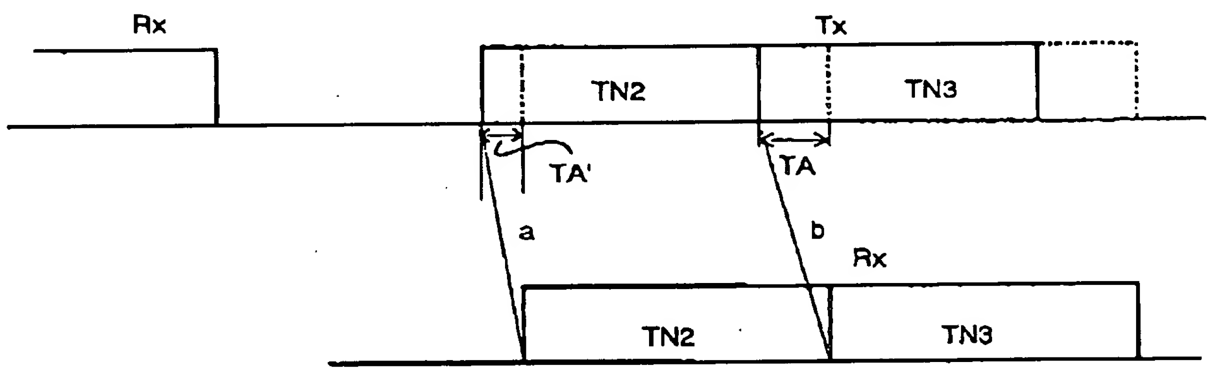
(54) Title: A TRAFFIC CHANNEL ARRANGEMENT USING TWO TIME SLOTS IN A MOBILE TELEPHONE SYSTEM



(57) Abstract

A traffic channel comprises two successive time slots in a frame in the uplink and in the downlink directions of which one time slot is a basic time slot, e.g. (TN3) and an additional time slot is a time slot (TN2) preceding it. In a mobile station there is thus one time slot between the reception and the transmission following it. In order that the radio unit of the mobile station would have time to settle into a transmission frequency, the base station times as a timing advance value (TA'; TA'') of the transmission burst, started in the additional time slot (TN2) of the mobile station, a smaller value than the timing advance value (TA) calculated by the mobile telephone system for the basic time slot (TN3) and times its reception correspondingly delayed. The transmission burst can be combined of two normal bursts of the GSM system by deleting the guard period between them and by using for both a timing advance value (TA', TA) of their own.

A traffic channel arrangement using two time slots in a mobile telephone system

The present invention relates to a traffic channel arrangement using two time slots in a mobile telephone system based on time division multiple access.

In the GSM system, one TDMA frame is 4.615 ms in length and comprises eight time slots which are numbered from zero to seven. The number of a time slot is indicated by the abbreviation TN (Time Slot Number). A full-rate traffic channel TCH comprises cyclically every eighth time slot so that with respect to the network, one carrier can comprise eight traffic channels. Traffic from a mobile station to a base station (Uplink Direction) and traffic from a base station to a mobile station (Downlink Direction) are arranged so that the reception at the base station takes place three burst durations later than the transmission. In that case, the number TN of the transmission time slot of the transmission frame and the number TN of the reception time slot are the same. This is illustrated in Figure 1 in which the upper part shows successive time slots of a mobile station near a base station. Rx indicates the reception time slot and Tx the transmission time slot. The transmission takes place three burst periods later than the reception. In the lower part of the figure, downlink indicates the reception of a mobile station and uplink the transmission.

Transmission takes place as a burst in a transmission time slot. The amplitude of a transmission signal rises during a time slot from the starting value zero to a nominal value after which the phase of the signal is modulated in order to transmit a bit packet.

After this, the amplitude of the transmission signal falls again to zero at the end of the time slot. A normal burst contains two sequences of 58 bits between which there is a training sequence of 26 bits. There are 3 tail bits at the beginning and at the end of a burst. So that the received successive bursts would not overlap, there is a guard period of 8.25 bits in length at the end of each burst. The actual duration of the guard period depends on the signal envelope of the transmission burst, but generally the guard period is specified as the time during which the burst signal is below -70 dB. The duration of the guard period is in that case about 30 microseconds. The guard period is needed because mobile stations transmitting on the same radio carrier are at a random distance from the base station, whereby the propagation time of radio waves from the base station to the mobile station varies specifically for each time slot. Therefore the duration of the bursts to be transmitted in time slots has to be a little shorter than the time slot so that the bursts transmitted in adjacent time slots would not overlap during the reception of the base station. In order that the guard period would be as short as possible, the system is specified to be such that the base station adjusts dynamically the transmission moment of each mobile station on the basis of the bursts received therefrom. The base station gives the mobile station a so-called timing advance TA according to which the mobile station adjusts the beginning of the transmission instant. Thus the time between the reception and the transmission is considerably shorter in a mobile station situated far from the base station than in a mobile station situated near the base station.

In accordance with the above and Figure 1, the

GSM system is optimized to use as a traffic channel a pair comprising one time slot in successive frames in the downlink direction and one time slot in frames in the corresponding uplink direction. Therefore, only one radio unit can be used in a mobile station which unit synthesizes various frequencies for the reception, transmission and monitoring of neighbouring cells. In order that the frequency synthesizer would be able to tune and settle into a new frequency so that the required frequency changes could be done, the transmission of a mobile station is specified to take place as shown above, delayed with respect to the reception. Correspondingly, there is still enough time left between the transmission and the reception for monitoring the frequencies of neighbouring cells.

A disadvantage of the above-described prior art traffic channel arrangement is that the use of one time slot of the frame to form one traffic channel facilitates only a very small capacity. In some applications it could be advantageous to have more capacity for the use of a mobile station. The application could be data transmission, for example. An arrangement has been put forth in which two successive time slots would be used for receiving and transmitting. It has not been feasible in practice as a problem with this arrangement would be that there is only one time slot, that is, a time period of about 577 microseconds between the reception and transmission. When considering the fact that the timing advance required by the transmission shortens this time period, the actual minimum time between the transmission and reception, taking into account the greatest correction used for propagation delay, will be only about 340 microseconds. This is an extremely critical time for a synthesizer to make a frequency hop of 45 MHz and

settle into a new frequency. Another way would be to use e.g. time slots 2 and 3 for the downlink direction and, correspondingly, time slots 3 and 4 for the uplink direction. In this case, the time between the transmission and reception of the mobile station is reduced to two time slots at its smallest during which time the radio units of mobile stations should make two great frequency hops, a fast hop from transmission to monitoring and from monitoring to reception. This is very difficult to implement. Also, the arrangement would waste resources as one time slot without a counterpart would remain to be unused in both directions. It is well known that the settling time of a synthesizer can be expedited by means of various circuits improving tracking, but these circuits may raise the price of the end product too much.

This invention shows an arrangement that makes it possible to use two time slots on a traffic channel without the above-mentioned drawbacks. The invention is characterized by what is stated in claim 1.

According to the invention, two successive time slots, e.g. time slots TN2 and TN3 are used for transmission during which time slots no guard period is used between the transmitted bursts. In two successive bursts guard period is not needed for distinguishing bursts from one another as both the transmission and the reception occur similarly timed for both successive bursts and the interference conditions change very little during this time. By utilizing the guard period in both transmission and reception directions, about 60 microseconds more tuning time is gained. In that case, the minimum time between the transmission and reception can be increased from 340 microseconds to about 400 microseconds. According to the invention, a shorter timing advance is used for the first burst than what

the network has calculated to be the timing advance in a normal case in which only one time slot is used.

According to the first embodiment, bursts are transmitted on both two successive time slots and both have a timing advance of their own. The reception of an additional time slot is delayed at the base station in proportion to its timing advance. A specific advantage of this solution is that the use and the structure of a normal GSM system need not be altered.

According to the second embodiment, the successive bursts of two time slots are combined into a continuous transmission. The base station times the transmission of the combined burst as early as possible and also, the reception as late as possible in the window formed by two time slots. The burst can be optimized at least by deleting the tail bits between the bursts. The arrangement according to this embodiment requires changes to the specification of the TA control of the timing advance in the normal GSM system.

The invention will be explained in more detail by means of the accompanying pictures, in which

Figure 1 illustrates the cycle of the time slots of mobile stations,

Figure 2 illustrates the time slots used in the arrangement of the invention,

Figure 3 illustrates the first embodiment of the invention,

Figure 4 illustrates the second embodiment of the invention, and

Figure 5 illustrates the time slots of the physical channel used by the mobile station.

Figure 2 illustrates successive time slots both in the uplink and in the downlink directions. In the uplink direction the transmission time Tx comprises

two successive time slots: a time slot TN3 used in the normal GSM system and a time slot TN2 preceding it. Correspondingly, the reception occurs in the reception time slot TN3 of the normal GSM system and in the time slot TN2 preceding it. The figure shows a case in which the mobile station is quite near the base station, whereby the timing advance is zero. Here the settling time Ts of the radio unit of the mobile station from the reception frequency to the transmission frequency is sufficient. But when the mobile station moves farther from the base station, the timing advance needed in the transmission increases and it will fast come to the point in which the timing advance takes up such a big part of the time between the transmission and the reception that the remaining part is smaller than Ts in which case the transmitter has not had time to settle into the transmission frequency when the transmission should already start.

The first embodiment of the invention illustrated in Figure 3 is based on the normal GSM basic structure in which the basic time slot is TN3. It is assumed that the network will operate at first as usual. The communication is performed by using only the basic time slot TN3 but when the need for transmission increases, the time slot TN2 is enabled. In that case the transmission occurs in two successive time slots and in both time slots a transmission burst of their own is transmitted, that is, during the transmission time Tx, two bursts are transmitted, both of which have a timing advance control of their own. The base station has in accordance with the normal GSM practice notified the mobile station of the value of the timing advance TA. The burst to be transmitted in the time slot TN3 is transmitted by using that timing advance TA which the network has calculated in the normal way for the time

slot TN3. A shorter timing advance value TA' is used for the time slot TN2 preceding the basic time slot TN3. The shortening can be made because there is no need to use a guard period of 8.25 bits in length between two bursts to be transmitted in the time slots TN2 and TN3. The beginning of the burst transmitted on the time slot TN3 with the timing advance TA coincides with the beginning of the second reception time slot TN3 of the base station receiver at the other end of the radio path, just as the system has calculated; this is illustrated with a broken line b. As the timing advance TA' is smaller than TA, the reception of the time slot TN2 is delayed at the base station as much as the timing advance of the first transmission burst is smaller than the timing advance of the second burst. Then the beginning of the bursts occurs at the beginning of the first reception time slot of the burst, just as it should, illustrated with a broken line a.

The deletion of the guard period between the transmission bursts and thus that TA'<TA, indicate an increase of about 4 kilometres in the maximum radius of the cell in comparison to the radius if the timing advance of the time slot TN2 would be TA. If the tuning time of a mobile station is normally in the technique used in the GSM system about 450 ms, the solution of this embodiment indicates that the size of the cell is doubled. It is essential for this solution that the reception of the additional time slot TN2 at the base station is delayed by a time equivalent to how much smaller the timing advance of the additional time slot is than the timing advance of the basic time slot TN3. The advantage of this first embodiment is based on the fact that no specifications varying from the normal GSM system are needed in the application of two time slots.

In the embodiment shown in Figure 4, the transmission in successive time slots occurs as one single burst. The successive bursts are linked into one burst illustrated with a line e by deleting the guard period of the first burst. Also, the tail bits at the end of the first burst and at the beginning of the second burst can be deleted without having an effect on the release algorithms of channel coding. Thus the duration of the burst can be shortened. The upper part of Figure 4 discloses the time slots TN2 and TN3 with a broken line and the lower part discloses a window formed by two reception time slots TN2 and TN3 during which time the transmitted combined burst is received. The pulse shown by a uniform line e is meant to illustrate the transmitted combined burst. The duration of the combined burst is shorter than the length of two time slots. Then the timing advance TA" of the burst is adjusted so that the end of the burst is as close as possible to the end of the reception time slot, the broken line c illustrates the mapping of the end part of the burst after the propagation time to the reception time slot. When the timing advance TA" has been adjusted in accordance with the condition above, the starting instant of the burst is mapped somewhat later than the starting instant of the receiving window. The base station adjusts its reception a little later in the window formed by two time slots.

In Figure 4, the sign TA refers to the timing advance which would be used when the traffic channel comprises one time slot. The sign Ts refers to the settling time of the radio unit of the mobile station when transferring from the reception to the transmission. In that case the transmission should start before the radio unit is ready for it. By combining the bursts and by using timing advance as

shown above, the radio unit still has enough time for tuning into the transmission frequency. It is essential in this arrangement according to the second embodiment that the base station times the transmission of its own combined burst as early as possible and also, the reception as late as possible, that is, TA'' should be as small as possible in the used window of two time slots. The timing of the reception according to this embodiment requires changes in the control specifications of the timing advance TA in the normal GSM system because otherwise, the timing advance TA'' of the mobile stations close to the base station could turn negative. The method can be applied also when other ways have been used, such as optimizing the channel equalizer to be more suitable for a dual burst, to reduce the number of bits transmitted over the radio path.

Figure 5 illustrates frequency changes in the use of two time slots. The timing advances of the transmission are shown by oblique strokes. The frequency transfers are per se in compliance with the normal GSM practice: the reception occurs in time slots 2 and 3, after that the frequency is changed and the transmission occurs in time slots 2 and 3, after the transmission the frequency of some neighbouring base station is monitored and the frequency is changed into a reception frequency. After this the cycle shown above is repeated.

The above explanation and the figures relating thereto are only meant to illustrate the present invention. The different variations and modifications of the invention are obvious to those skilled in the art without deviating from the scope and spirit of the invention disclosed in the appended claims.

Claims

1. An arrangement for increasing the capacity of a traffic channel in a TDMA mobile telephone system in which a frame transmitted from a mobile station to a base station (uplink direction) and a frame transmitted from a base station to a mobile station (downlink direction) comprises several time slots (e.g. TN0,..TN7) of which one time slot (e.g. TN3) is a basic time slot,

characterized in that

the traffic channel comprises two successive time slots of frames in both directions of which one is the basic time slot and an additional time slot is a time slot preceding it so that in a mobile station there is one time slot between the reception and the transmission following it,

the base station times as a timing advance value (TA';TA") of the transmission burst, started in the additional time slot of the mobile station, a smaller value than the timing advance value (TA) calculated by the mobile telephone system for the basic time slot and times its reception correspondingly delayed.

2. An arrangement according to claim 1, characterized in that during two successive time slots two successive bursts are transmitted so that the burst transmitted in the basic time slot is transmitted by using the timing advance value (TA) of the basic time slot and the burst transmitted in the additional time slot is transmitted by using a smaller timing advance value (TA') than said timing advance value (TA), whereby the base station starts the reception of the burst transmitted in the

additional time slot delayed in proportion to the difference between the timing advances.

3. An arrangement according to claim 2, c h a r a c t e r i z e d in that two successive normal bursts are transmitted in two successive time slots processed so that there is no guard period between them.

4. An arrangement according to claim 1, c h a r a c t e r i z e d in that

a continuous burst is transmitted during two successive time slots so that the timing advance value (TA") used for it is smaller than the timing advance value (TA) calculated by the mobile telephone system for the basic time slot,

the used timing advance value (TA") is specified to be such that the reception of the base station occurs as late as possible in the window formed by two reception time slots.

5. An arrangement according to claim 4, c h a r a c t e r i z e d in that the continuous burst is comprised by combining two normal bursts and by deleting the guard period between them.

6. An arrangement according to claim 5, c h a r a c t e r i z e d in that the tail bits at the end of the first burst and at the beginning of the second burst have been deleted.

7. An arrangement according to claim 4, c h a r a c t e r i z e d in that a channel equalizer is optimized to be suitable for a dual burst in order to reduce the number of the bits to be transmitted over the radio path.

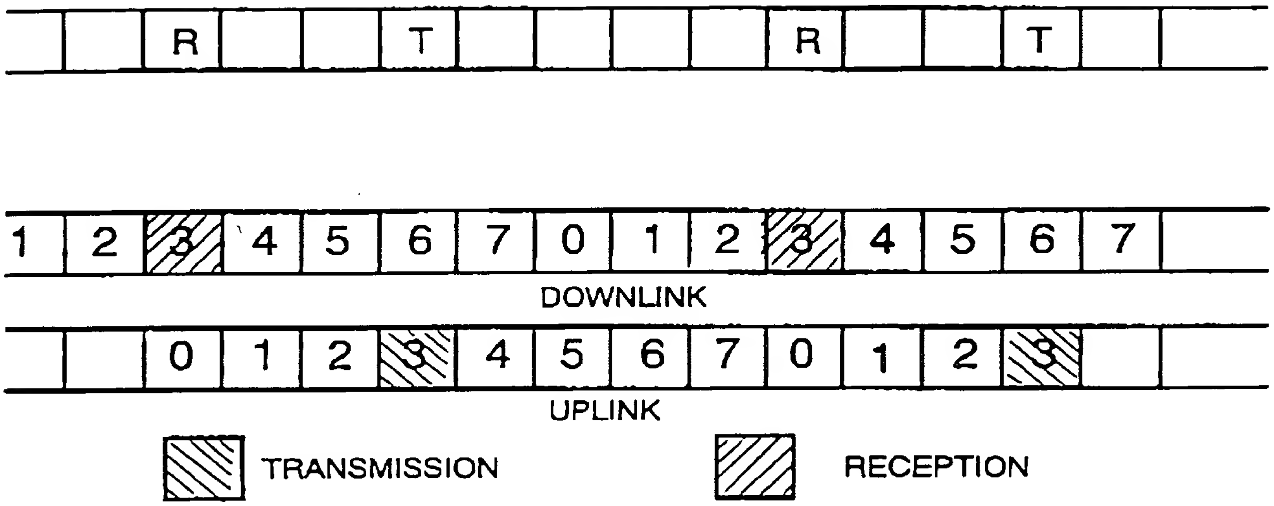


Fig. 1

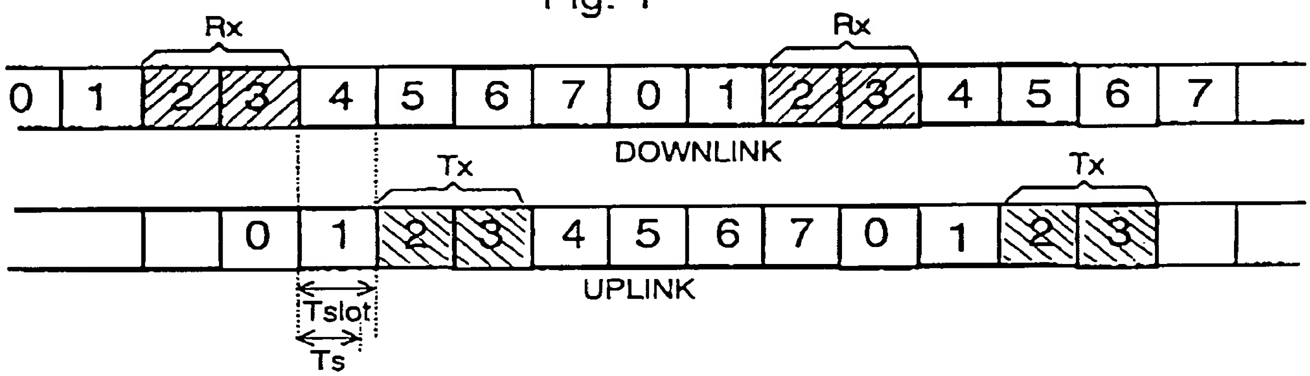


Fig. 2

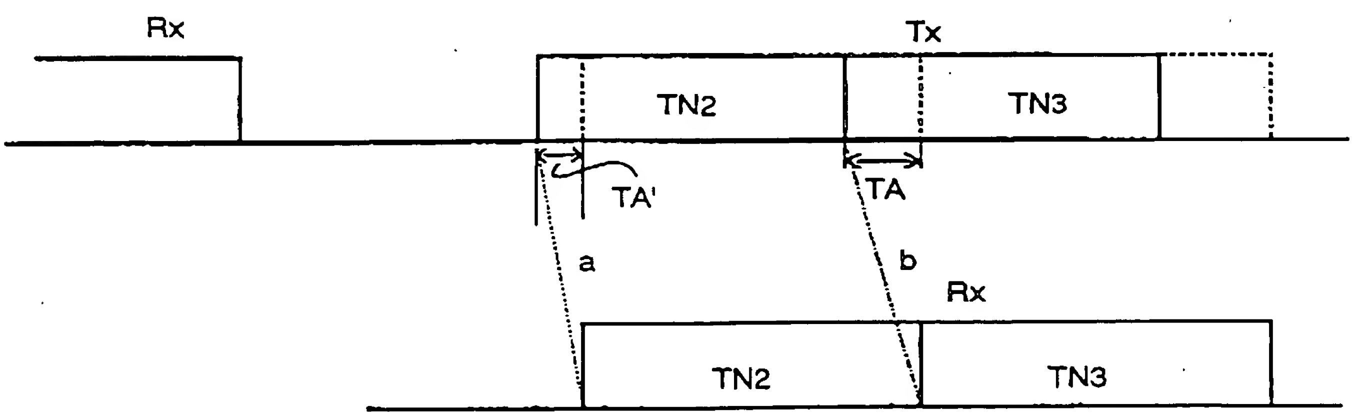


Fig. 3

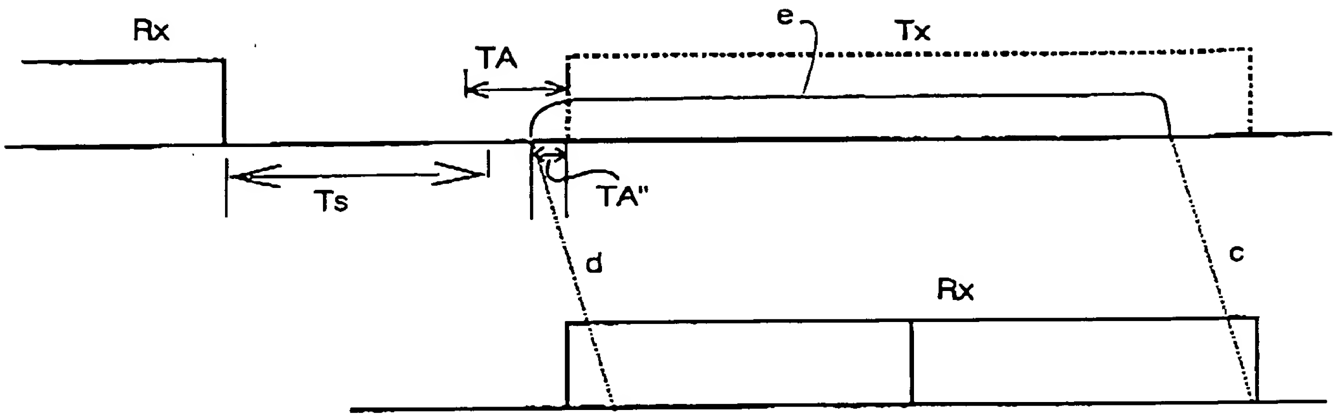

Rx
e
Tx
TA
Ts
TA"
d
c
Rx

Fig. 4

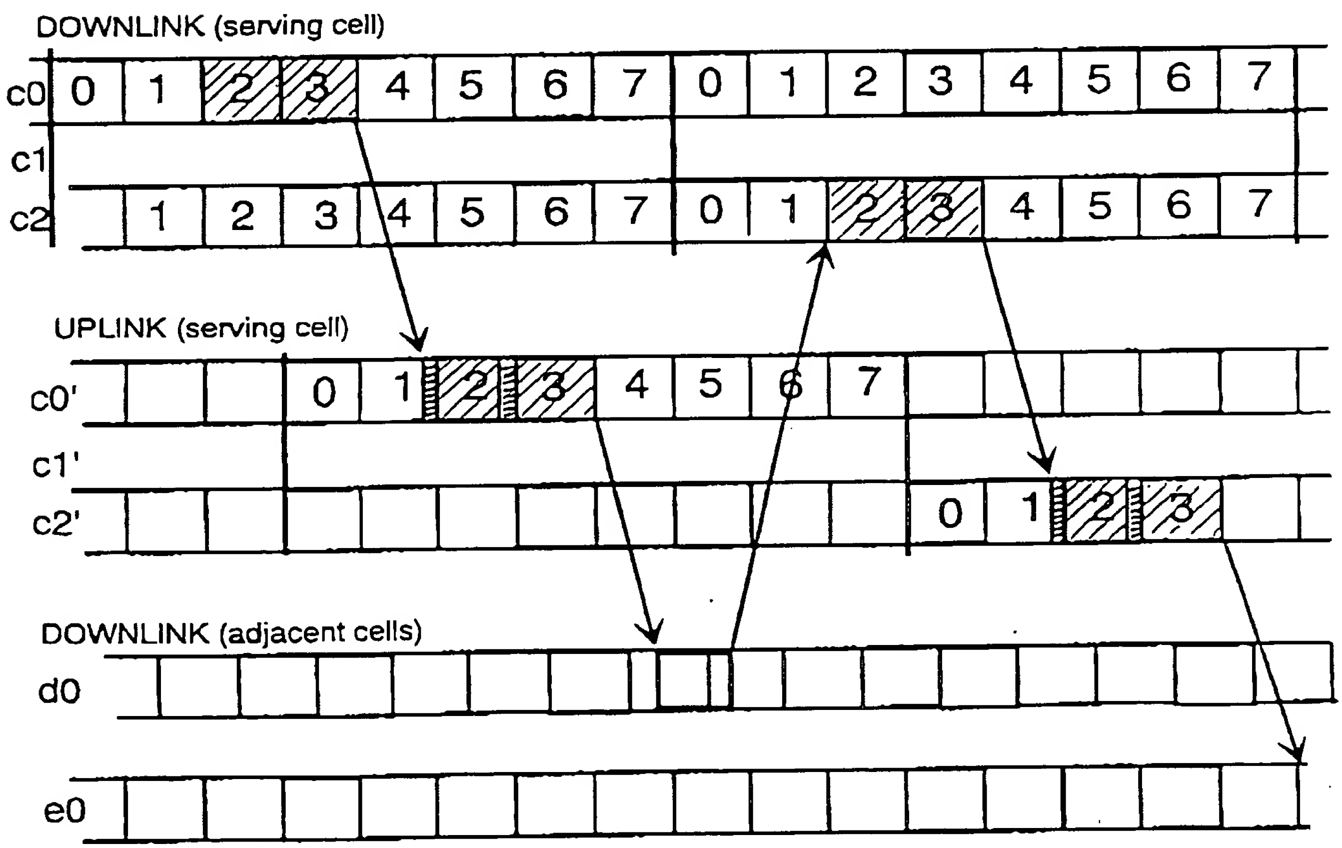

DOWNLINK (serving cell)
c0
0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
c1
c2
1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
UPLINK (serving cell)
c0'
0 1 2 3 4 5 6 7
c1'
c2'
0 1 2 3
DOWNLINK (adjacent cells)
d0
e0

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 95/00680

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/30, H04B 7/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04Q, H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO 9502306 A1 (NOKIA TELECOMMUNICATIONS OY), 19 January 1995 (19.01.95), page 2, line 8 - line 10; page 6, line 3 - line 23; page 7, line 24 - line 27 --	1-2
P,A	WO 9531878 A1 (NOKIA TELECOMMUNICATIONS OY), 23 November 1995 (23.11.95), page 4, line 12 - line 20; page 9, line 34 - page 10, line 5 --	1
A	US 4937819 A (KING), 26 June 1990 (26.06.90), column 3, line 45 - line 49 -- --------	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

01/04/96

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A1- 9502306	19/01/95	NONE	
WO-A1- 9531878	23/11/95	NONE	
US-A- 4937819	26/06/90	NONE	